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STRATEGIES FOR AN INTEGRATED DEVELOPMENT OF AGRICULTURE THROUGH LOCAL MANUFACTURE OF MACHINERY AND EQUIPMENT RELATED TO WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE BY SMALL- AND MEDIUM-SCALE MANUFACTURERS IN AFRICA *

Prepared by

the UNIDO Secretariat

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PREFACE

In recent years the African countries have been unable to meet the ever-increasing demand for food through domestic production. This continued worsened situation has compelled almost all African countries to seek food aid and imports in order to try to maintain the essential dietary energy supply, which is currently declining to below the required level in some 28 African countries.

The continued droughts in Sub-Saharan Africa, e.g. Eastern and Southern Africa, Western African and part of the Northern and Central African subregion during the recent years have culminated in a drastic shortage of food, particularly staple cereals, due to insufficient production by rain-fed agriculture.

During 1980-1983, there was an annual per capita decline of 2.7 per cent in total agricultural production, with a consequent decline of 2.9 per cent per person of food production. This has resulted in a widening food-population gap which, for all Africa, has shown an annual deterioration of 1.3 per cent during the decade 1971-1980.

The critical food situation in Africa and the prospects for 1985 and 1986, which are being discussed in various meetings, clearly indicate severe declines in all the African subregions. The immediate consequence has been that 24 African countries have experienced food deficits totalling 5.4 million tons during 1983/84. Recently, Food and Agriculture Organization of the United Nations (FAO) has identified 21 countries facing critical food shortages in 1984/85 whose combined cereal production is likely to be 23 per cent below normal.

In this state of crisis, the situation has been further aggravated by the lack of agricultural infrastructure, particularly to provide adequate alternative sources of water to vast areas affecied by long periods of dry weather. Water conservation, water supply and irrigation activities were not given adequate attention by African planners and policy makers during the last few decades, particularly for food and staple cereals production. Such a situation could have been avoided if adequate planning and implementation programmes had been carried out for the effective use of flood water, ground water, canal and river water, and operative diversion of water available in the African lakes for intensive agriculture throughout the arid, semi-arid or humid tropical regions. These programmes would require, on the one hand, the introduction of a wide range of devices, techniques, methods and the development of a network of water supply arrangements, and, on the other hand, local manufacture and subsequent application of a wide variety of machinery and equipment for adequate storage, supply and distribution of water to farmlands for effective irrigation and drainage. Thus, the scope of irrigation extends from the watershed to the farmlands; its effective method of control and the disposition of excess and waste water have vital significance for intensive agriculture.

These objectives can only be achieved by undertaking continuous study, survey, investigation, research and development and inter-country co-operation for intensifying the building of dams, small earth dams, earth canals, lined canals, ground water reservoirs, ponds, wells and related facilities for water catchment in order to supply sufficient water to farmlands when rain-fed agriculture is inadequate.

In order to build up an irrigation and drainage infrastructure, it is essential to expand the building materials industries along with the engineering and allied metalworking industries, and to promote the local manufacture of cement, bricks, tiles, fired clay products, steel sections, pipes of various materials, water fittings, hardware, hand pumps, diesel engines, electric motors, water pumps, submersible pumps, windmill pumps, solar energy pumps, animal-drawn pumps, irrigation equipment, agricultural implements, hand tools etc.

The present paper examines the scope of engineering products that can be manufactured in existing small- and medium-scale industries in selected African countries. The integrated and interlinked development of these manufacturing industries will create a permanent base for supplying the future requirements of engineering inputs needed for effective irrigation and drainage, particularly in the arid and semi-arid crisis areas of Africa.

I. INTRODUCTION

Persistent drought, famine, desertification and other natural calamities have contributed to a great extent to the deterioration of the situation in African agriculture, particularly the food production sector. Due to this climatic change, rain-fed agriculture has been greatly affected in all African countries in general, and in the arid/semi-arid regions in particular. As an alternative to rain-fed agriculture, the systematic application of irrigation may have an important role to play in the future agricultural strategy of African countries, particularly in the drought-affected regions.

Irrigation is generally defined as the measured application of water to soil for the purpose of supplying the moisture for plant growth. This controlled supply of water for farming is done by irrigation and drainage in order to make up for deficiencies in the natural moisture conditions of soil and its inherent drainage properties. Therefore, water for irrigation is supplied to supplement the water already available from precipitation, atmospheric water other than precipitation, flood water and ground water.

During dry periods, when rain-fed agriculture is impossible, it is necessary to secure alternative sources of water, particularly in the arid and semi-arid African regions. In the humid tropical region attention should be given to the establishment of adequate drainage infrastructure and the re-utilization of drainage water for second-crop production during the dry seasons.

The techniques of water conservation, conveyance of water, irrigation and drainage of excess water require sources of water, as well as irrigation equipment, machinery, structures, facilities etc. on the one hand, and on the other hand, the introduction of integrated policies and strategies for water resources investigation, field experimental plots, soil moisture studies, analyses of irrigation methods, studies of the inflow and outflow of streams, canals and dams, and the introduction of legal and administrative measures related to irrigation and drainage etc. at the national and inter-country levels.

Input requirements for irrigation and drainage

(a) Water conservation for irrigation

The development of water conservation to make possible the timely availability of water resources (other than rain-fed agriculture) can be achieved by the following means:

- studies of valley and mountain precipitation and water resources;
- constructing surface reservoirs;
- building small earth dams on streams, canals and rivers;
- saline-water conservation;
- extraction of ground water;
- recharging of ground water reservoirs;
- digging wells for irrigation water;
- water catchment improvisation, e.g. creation of ponds, small lakes, etc.;
- utilization of existing lakes.

(b) Conveyance of water for irrigation and drainage

The conveyance of water from the water sheds to the farmland for irrigation can be accomplished by the construction of:

- earth canals;
- lining canals;
- concrete pipes, plastic pipes, vitrified clay pipes, hoses, steel pipes, cast iron pipes, etc.;
- pumping water;
- furrowing farmlands;
- open drains;
- tile drainage systems;
- pumping for drainage.

(c) Irrigation and drainage

Irrigation and drainage can be carried out by:

(i) Surface irrigation

- furrow method of irrigation;
- sprinkler irrigation;
- flood irrigation (check flooding, basin flooding, etc.).

(ii) Subsector surface irrigation

- controlled by lateral supply ditches;
- uncontrolled, from excess application of water to adjacent or higher land (step farming).

(iii) Drainage

- open and closed drains;
- pumping equipment for drainage;
- re-use of drainage water.

(d) Machinery and equipment

In order to create the infrastructure facilities for effective irrigation and drainage systems, and to provide for the self-sustained development of these important agricultural operations, it is necessary to manufacture the essential equipment, machinery, structural devices and ancillary products.

Local manufacture of the machinery, equipment and structures needed for conservation, conveyance, irrigation and drainage of water requires the following:

- A wide range of construction machinery and equipment, e.g. earth removers, loaders, levellers, scrapers, drag line excavators, cranes, tractors, etc.;
- Manual digging tools and equipment;
- Cement, bricks and concrete sections;

- Steel sections and fabricated structures;
- Cast iron products;
- Hardware items;
- Pipes and fittings (metallic and non-metallic);
- Valves and joints;
- Diesel engines, electric motors and pumps;
- Brass sprinklers and fittings;
- Agricultural implements, e.g. harrows, disc ploughs, tillers, levellers furrow etc.;
- A variety of agricultural hand tools;
- Windmill and pumps;
- Solar pumps;
- A wide range of products of ancillary engineering industries.

The local development and manufacture of the above engineering products require the promotion, expansion and upgrading of existing engineering and allied metalworking and selected building materials industries in African countries. In order to achieve these objectives it is essential to reorient policies and strategies to promote the integrated development of the building materials, metal and engineering industries directed towards the local manufacture of irrigation and drainage system equipment.

An important measure for achieving this is through the creation and expansion of multi-purpose production units at the small- and medium-scale enterprise level. Other factors to be considered relate to the promotion of inter-country and interregional co-operation for self-sustained development in the future manufacture of irrigation and drainage equipment.

II. NATIONAL POLICIES AND STRATEGIES FOR THE DEVELOPMENT OF SYSTEMS FOR WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE IN AFRICA

The majority of African Governments recognize the importance of water resources development, particularly related to water conservation and conveyance, irrigation and drainage, and especially the essential role of water resources development to attain self-sufficiency in food and agricultural production. Consequently, high priorities are being accorded to water resources development in the national development plans of almost all the African countries. Most of the relevant national policies are directed towards:

(i) Providing domestic water supplies for human consumption;

(ii) Construction of simple system wells (with low operating and maintenance costs);

(iii) Provision of water to the most needy people;

(iv) Maximum development and efficient use of water resources for socio-economic benefits;

(v) Development of irrigation, hydro-power generation and water resources research.

Many countries lack an overall national policy to oversee the development and management of their water resources. Instead, each water institution in the country follows its own sectoral water policies to achieve its development target. The general policies of water resources development cover institutional arrangements at the national level. Most of the strategies for water resources development and its ultimate end uses are directed through:

- agricultural and rural development schemes;
- irrigation lending;
- increasing available lands under irrigation;
- rehabilitation of existing water resources activities;
- government legislation governing water resources development and utilization;
- water resources assessment;
- manpower assessment and development.

Gaps between the needs of water resources development and the industrial sector responsible for the development of machinery and equipment for water supply and irrigation

The most disturbing feature of existing national policies and strategies for water resources development in African countries has been the total neglect of measures to link policies for water resources development and downstream applications with the industrial development policy. The existing policies and strategies do not spell out clearly the interlinked requirements for devices, facilities, equipment and machinery, and which of those can be locally manufactured at the national level to fulfil the needs, inter alia, of water resources development, irrigation and drainage etc.

Such omissions at the policy level have created considerable failures in achieving water target requirements, particularly in the agricultural sector. Due to the lack of interlinked planning of water resources development activities with the related manufacturing sector, most African countries are unable to produce products such as pumps, agricultural implements, diesel engines, pipes, fittings, construction, equipment and other types of machinery and equipment required for water conservation and conveyance, irrigation and drainage. There are only a few countries, such as Zimbabwe, Kenya and Egypt, that have some kind of policy measures to interlink the activities of the local manufacturing sector and water resource development. These countries also manufacture a wide range of water lifting, irrigation and drainage equipment.

The gap existing in most countries has been further widened by the lack of basic manufacturing support facilities within the industrial sector, e.g. foundry, forging, heat treatment, machine shop, tool-room and metal coating facilities etc., in the majority of African countries. Owing to the absence of these core industries, many African countries are unable to manufacture simple equipment such as hand pumps, water fittings, fabricated irrigation water control devices, agricultural implements etc.

There is thus an urgent need in all African countries to integrate at the policy and strategy level the interlinked activities related to the development of water resources engineering, and the building materials, engineering and allied metalworking industries. Such improved policy measures will open up new avenues for the integrated development of water resources and contribute to the industrialization and agricultural development of African countries.

III. TRENDS IN THE USE OF EQUIPMENT FOR WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE IN SELECTED AFRICAN COUNTRIES

African agriculture is based mainly on rain-fed and river basin irrigation in the majority of the Sub-Saharan countries. North of the Sahara, the irrigation pattern is based on water available from the ground and river basin. Before commenting on the current use of water supply and irrigation equipment in the African region, it is necessary to describe briefly the topographic, climatic and hydrographic factors influencing the irrigation and drainage patterns in this vast continent.

Brief overview of topography, climate and hydrography of the African continent

According to the topographic features, the African territory may be divided into two parts, the lowland in the North-West with elevations of predominently below 1,000 meters and the highland in the South-East, with elevations often exceeding 1,000 meters. The following geographical regions are usually recognized in Africa: the Atlas Mountains, the Sahara Desert with the Nile Valley, Sudan, North Guinea Upland, Congo Basin, Abessomali, East Africa, Southern Africa and the Islands.

The climate of Africa is chiefly determined by its geographic position, i.e. north and south of the equator, with vast areas located in the tropics. The African continent is the hottest one, the climate of its northern part is warmer than that of the southern; north and south of the tropics, the quantity of precipitation gradually decreases. In northern Africa the mean annual precipitation does not exceed 10-20 mm. In the southern African region the distribution of precipitation is uneven; the precipitation brought by the Indian Ocean tradewind varies from 500-1,000 mm; in the western part of Southern Africa precipitation amounts to 0-500 mm. The equatorial monsoon zone in the Northern Hemisphere is notable for less precipitation during the rainy season. The equatorial monsoon zone in the Southern Hemisphere occupies only the eastern part of the continent; the mean annual precipitation there ranges from 500 to 4,400 mm.

To understand the formation of the ground water it is important to know the amount of precipitation that reaches the water table, i.e. the amount that contributes to the ground water recharge; this amount varies in the different climatic zones of Africa.

The most dense drainage pattern in Africa is observed in areas of maximum precipitation. In the desert areas it is practically absent. Since all the rivers of the continent are mainly rainfall recharged, the difference between their minimum and maximum discharge is great. Owing to the water scarcity in the arid and semi-arid areas irrigation is impossible. Farmers in these areas generally rely greatly on the ground water supply for agricultural uses.

The drainage system of Africa belongs to the drainage basins of the Indian Ocean (18.48 per cent); the Atlantic Ocean (36.05 per cent); the Mediterranean Sea (14.88 per cent); as well as to Island Basins (30.59 per cent). The characteristic of the river basins is that the areas of the basins with run-off towards the seas and oceans tend to enlarge. In most of these tropical African areas agriculture is intensive wherever adequate drainage facilities exist.

The ground water recharge of African rivers is low. It is only 20 per cent in Congo and Niger, and in tropical areas where soil permeability is good, e.g. in East Africa, the ground water run-off increases to 50-60 per cent. With considerable overland run-off having low ground permeability in the tropical humid forests of Africa, the ground water recharge of rivers decreases to 20-30 per cent. The ground water run-off also reflects the rainfall regimes.

Different types of irrigation in the geographical regions of Africa

Within the varied conditions - topographical, climatic, hydrographical and particularly the rainfall regime - of the African continent, the water conservation, water conveyance, irrigation and drainage system applications vary widely, from rain-fed agriculture and drainage in the humid tropical part, to ground water requirements in the arid and semi-arid parts of the continent.

The African irrigation systems can best be divided into the following groups:

- Water supply and irrigation in the arid, i.e. desert areas;
- Water supply and irrigation in the semi-arid areas;
- Water supply and irrigation in the heavy rain-fed agricultural areas (where drainage is required to dispose of unwanted water during monsoon time that can be stored for a second crop in the dry season irrigation);
- Water supply and irrigation in the river basins.

Choice of different types of machinery, equipment, and devices for irrigation and drainage in African Countries

As mentioned before, the conservation and conveyance of water, irrigation and drainage play an important role in crop production where rain-fed agriculture is difficult. As the systems of irrigation and drainage are different in the different parts of the African continent, it is essential to note that a wide range of techniques, equipment and machinery are being used in different countries and regions. At present, the majority of the African Governments have undertaken a large number of construction and irrigation projects. As water resources are public property, Governments are the only entities to assume the responsibility for the appropriate and beneficial use of water.

During the scarce period of rain-fed agriculture, it is necessary to secure an alternative source of water, particularly in the arid and semi-arid African regions. In the humid tropical region, greater attention should be given to the establishment of adequate drainage systems. These alternative sources of water other than rain-fed agriculture, which are described in chapter I.(a), (b) and (c) of this paper, are used to create an integrated infrastructure for water conservation and conveyance, irrigation and drainage systems. Currently, the following equipment, machinery and devices are being used in Africa for these systems:

A. Water Conservation

1. Surface Reservoirs

(a) Purpose: Surface reservoirs are built to store irrigation water. The storage dams are built with spillways large enough to convey maximum anticipated flood flows. Capacities vary from a few thousand acre-feet for reservoirs on small streams to millions of acre-feet, e.g. The Aswan High Dam, the Akosomba Dam, the Bakolori Dam etc. Likewise, dams constructed vary from a few feet in height, built at low cost, to massive masonry structures over 700 feet high and built at a cost of millions of dollars.

(b) Equipment used

- Heavy earth-moving equipment;
- concrete mixers;
- piling equipment;
- conveyors and mechanical handling equipment;
- cranes, hoist etc;
- transport equipment.

(c) Trends in Africa: Only a few African countries have facilities to build dams. There are two new projects recently undertaken, i.e. Kagera River Project and Niger River Project.

2. Small Earth Dams

(a) Purpose: Small dams are valuable for impounding water from springs and small streams so that it can be more efficiently utilized. The spillway is a very critical segment of the design and is the feature which often causes failure of these types of dams in the African region.

(b) Equipment used

- Metal fabricated portable irrigation control gates;

- Pre-fabricated low cost water control structures manufactured from steel sections;

- Concrete three way outlet boxes on irrigation laterals;

- Portable rectangular weirs made from canvas or plastic and utilizing sheet metal for the notch (generally not being used in Africa);

- Wide range of hand tools.

(c) Trends in Africa: Many African countries have installed such small earth dams for irrigation.

3. Rain-making or cloud-seeding

Many countries, such as Ethiopia, have undertaken forest plantation projects for rain-making.

4. Saline-water conversion

(a) Purpose: This technique is mostly used in the desert coastal areas where fresh water is produced by boiling and subsequently condensing sea water. To remove salt from 1,000 gallons of sea water requires at least 2.8 kWh (3.8 hp.hrs) of electrical or solar energy. Similarly, 900 kWh (more than 1,200 hp.hrs) are required to obtain one acre-foot of fresh water, at an equivalent cost of US$20. This technique is used mostly for domestic purposes.

(b) Equipment used

Sea water to fresh water generator, using diesel oil or solar energy.

(c) Trends in Africa: This process is used in some North African countries to provide water for domestic consumption.

5. Utilization of ground water reservoirs

(a) Purpose: Many African countries, particularly in arid and semi-arid areas, are using this technique for the supply of irrigation water. Pumping water from underground sources is widely practiced in African countries and is a well-established method of obtaining irrigation water. The silting-up of reservoirs, the availability of good ground water storage sites, the growing lack of surface storage sites, the prevention of evaporation and the development of additional water will all contribute to more extensive and intensive development of underground water use.

(b) Equipment used

- Well-drilling machinery and equipment;
- Well-drilling tools, e.g. rope socket, jars, drill stem, drilling bit, bailer etc.;
- Pipes, fittings, valves etc.;
- Pumps, (ref. A.4. in this chapter, p.16).

(c) Trends in Africa: This is a new trend in Africa. A large number of countries, particularly in the arid and semi-arid areas, have introduced these facilities, e.g. North African countries, Southern African countries, West African countries.

6. Wells for irrigation water

(a) Purpose: Dug wells have been the principal source of water until recent times in the African region, when modern well-drilling methods have been developed, imported and used extensively. Dug wells are usually shallow wells, generally less than 50 feet in depth and several feet in diamater.

The Ranney well is a modification of the dug well, where a large central shaft is constructed to a depth below the water table. Wells are then drilled horizontally in a radial direction from the bottom of the shaft. Large quantities of water can be obtained from this type of well. The importance of wells and ground water development is indicated by the size of the well-drilling industry.

(b) Equipment used

- Power soil sampler capable of obtaining a 4-inch undisturbed core;
- Hand tools and buckets;
- Extracting equipment with clamshell or orange peel buckets attached to the equipment;

- Well-drilling tools for cable-tool methods, e.g. rope socket, jars, drilling stem, drilling bit, bailer etc.;
- Hydraulic rotary equipment;
- Reverse rotary equipment;
- Transport equipment.

(c) Trends in Africa: Wells are traditionally used for supplying water for domestic and irrigation purposes. Dug wells are available in almost all parts of Africa, particularly in rural villages. Most of the dug wells are created by manual efforts.

B. Conveyance of water

The following are existing technologies for the conveyance of irrigation and drainage water.

1. Earth canals

(a) Purpose: The common types of water conveyance are the irrigation canals extensively used in the African region. The canals are excavated in natural materials along the line that water must be conveyed. Excessive velocities of water in earth canals may cause erosion.

(b) Equipment used

- Hand tools and buckets;
- Power-operated ditching equipment.

(c) Trends in Africa: Only a few countries in Africa designed their irrigation systems with earth canal networks. Short-stretch canals are used for surface irrigation only in most of the countries.

2. Lined canals

(a) Purpose: Many irrigation canals are lined for:

- Decreasing conveyance seepage losses;
- Providing safety against breaks;
- Preventing weed growth;
- Retarding moss growth;
- Decreasing erosion caused by high water velocity;
- Cutting down maintenance costs;
- Reduction of drainage problems;
- Increasing the capacity to convey water.

(b) Equipment used

- Machinery for the manufacture of pre-cast concrete slabs;
- Concrete mixers;
- Equipment for sizing masonry rocks;
- Equipment for manufacturing bricks etc.;
- Hand tools and buckets;
- Power-operated ditching equipment.

(c) Trends in Africa: Very few African countries. e.g. Egypt, Zimbabwe, Kenya, Côte d'Ivoire etc. have lined canal networks for irrigation; among all the African countries Zimbabwe has the best network of lined irrigation canals.

3. Delivery of water by pipes

(a) Purpose: This method is extensively used in the African region for the delivery of water by:

- concrete pipes;
- plastic pipes;
- steel pipes;
- vitrified clay pipes;
- hoses;
- flumes of concrete or aluminium;
- siphons for diverting water from concrete lined ditches;
- spun cast iron pipes;
- bamboo flumes etc.

(b) Equipment used

- Pipe-laying machinery;
- Pipe-expanding machinery;
- Pipe-thread-cutting machinery;
- Welding equipment;
- Concrete-joining devices;
- Ditching machinery;
- Hoists and cranes;

- Concrete mixers;
- Transport equipment;
- Hand tools and bucekts;
- Hardware and mechanical tools.

(c) Trends in Africa: Both concrete and steel pipe manufacturing facilities exist in the majority of African countries. Owing to the lack of ancillary hardware industries, the conveyance of water by means of pipes is limited to urban areas for domestic use. Only a few countries have extensively used pipes for conveying water, e.g. Kenya, Zimbabwe, Mauritius, Zambia etc.

4. Pumping water for irrigation and drainage

(a) Purpose: There are large areas of land in arid and semi-arid regions of Africa so situated that available water cannot be brought to them by gravity. For many of these areas, water is raised by some mechanical device from its natural sources, whether surface or underground, to the elevation of the higher parts of the land, so that water will flow for irrigation by gravity. The pumping for raising water is known as irrigation pumping. Sprinkling irrigation also requires pumping of water. Pumping for drainage is as important as for irrigation.

(b) Equipment used

(i) Prime movers for pumps:

- windmill arrangements;
- solar energy motors;
- electric motors;
- single-, double- or three-cylinder diesel;
- petrol or gas engines;
- steam engines and steam turbines (generally for large plants).

(ii) Pumps:

- centrifulgal pumps (horizontal and vertical types);
- deep-well turbine pumps;
- submersible turbine pumps;
- propeller and mixed flow pumps;
- rotary pumps;
- open and closed diaphragm pumps;
- reciprocating pumps generally used with windmills;
- pelton wheels;
- hand pumps.

(c) Trends in Africa: The concept of integrated irrigation pumping stations does not exist in the majority of African countries, except in Egypt, Ghana, Uganda, Kenya, Zimbabwe, Zambia etc., where such facilities are incorporated to irrigate large areas. The recent use of submersible pumps for irrigation has been encountered in Zimbabwe, Kenya, Nigeria, Côte d'Ivoire, Egypt etc. For surface irrigation, centrifugal pumps driven by diesel engines are being used for cash crop production. Hand pumps are used in most of the Eastern, Southern and Western African regions.

5. Fittings for water supply

(a) Purpose: The control of irrigation water requires control valves, lines and fittings throughout the water conveyance system. These include:

(i) Valves, e.g. globe valves, gate valves, angle valves, swing check valves, taps etc.;

(ii) Bends and elbows, e.g. close return bends, standard tees, standard elbow, medium sweep elbow, long sweep elbow, square elbow, borda entrance, sudden enlargement, ordinary entrance elbow etc.

(iii) Hardware, e.g. bolts, nuts, stays, clamps, gaskets, washers, clips, chain clips, grouting bolts, foundation bolts, couplings, springs etc.

(b) Equipment used

- Mechanical hand tools;
- Pipe-bending machines;
- Pneumatic spanners and tools;
- Testing equipment;
- Thread-cutting machines.

(c) Trends in Africa: The majority of African countries do not have facilities for the local manufacture of water fittings and valves. Only a few countries, i.e. Kenya, Zimbabwe, Zambia, Mauritius, Uganda, Tanzania, Egypt and Nigeria have such facilities.

C. Irrigation and drainage

1. Surface and sub-surface irrigation

(a) Purpose: Irrigation methods vary in different parts of Africa and on different farms within a community because of differences in soil, topography, water supply, crops and customs. Generally, African farmers carry out surface irrigation, i.e. (i) uncontrolled flooding; (ii) controlled flooding with corrugations, borders, checks or basins; (iii) furrows. Sub-surface irrigation has limited application in the African countries, i.e. (i) controlled by lateral supply ditches; (ii) uncontrolled from excess application of water to adjacent or higher land (step farming), only used in highland countries, e.g. Ethiopia, Lesotho etc.

(b) Equipment used

(i) Lifting and delivery of water by pumps

- lever-type hand pumps;
- rotary hand pumps;
- animal-drawn pumps;
- windmill pumps;
- engine-driven pumps (centrifugal);

- electric motor-driven pumps;
- tractor-driven pumps;
- submersible pumps;
- vertical turbine pumps.

(ii) Land preparation for irrigation

Extensive use of animal-drawn and power-operated implements for levelling, making borders, construction and cleaning of ditches, and for making corrugation and furrows.

- hand tools, e.g. hand spades, digging forks, hoes, hand cultivators etc.;
- animal-drawn cultivator tines, ridging ploughs, disc harrows, land-levelling blades etc.
- power-operated multi-purpose blade terracers, ridgers, disc ploughs, disc harrows, scrapers, levellers, deep furrow implements etc.

(c) Trends in Africa: In general, the surface and sub-surface irrigation are not mechanized in most countries of Africa. Although some African countries manufacture animal- and power-operated implements, e.g. Kenya, Zambia, Zimbabwe, Egypt, Algeria etc., the majority of African countries use hand tools or animal-drawn implements for land preparation for irrigation. Only a few African countries, e.g. Zimbabwe, Egypt, Algeria, Kenya manufacture/assemble submersible pumps and conventional pumps for irrigation. A large number of countries manufacture hand pumps, mostly used for domestic purposes.

2. Sprinkler irrigation

(a) Purpose: Sprinkler irrigation is the method of applying water to the surface of the soil in the form of spray (simulating ordinary rain), known as sprinkling. Sprinklers have been used on all soil types, on lands of widely different topography and slopes, and for many crops. There are two types of sprinkler systems, i.e. semi-permanent installations and portable systems. There are three types of sprinklers, e.g. fixed nozzle attached to the pipes, perforated pipes and rotating sprinklers. For effective irrigation, sprinklers are used with pumps having a water pressure from 5 psi (pounds per square inch) to 100 psi.

(b) Equipment used: Sprinkler systems include:

- Pumps of various types;
- Pipes and fittings mainly for riser pipes, lateral distribution pipes and the mainline pipes to be connected with the pumping plant;
- Fixed-nozzle sprinklers;
- Perforated pipe sprinklers;
- Rotating boom sprinklers.

(c) Trends in Africa: Sprinkler irrigation is mainly used for irrigation in the North African countries for crop production. In the Eastern and Southern African regions, sprinkler irrigation is mostly used in cash crop agriculture. Extensive sprinkler irrigation is used in Mauritius, Zimbabwe and Kenya. Sprinkler equipment is manufactured in Zimbabwe, Kenya, Mauritius, Egypt and Algeria. Sprinkler irrigation is still not widely used in the majority of African countries.

3. Drainage of irrigated lands

(a) Purpose: Drainage is the reduction of excess water. Irrigation and drainage in arid regions of Africa are complementary practices. In humid regions drainage is required to drive out excess water not required after irrigation. Adequate drainage improves soil structure and increases and perpetuates the productivity of soils. The introduction of a good drainage system for irrigated land requires (i) a source of excess water; (ii) control of the water source; (iii) lowering the water table. There are two types of drains - open drains and tile drains. In African countries open drains are mostly used for irrigated lands. It is to be noted that in the arid regions drainage usually follows irrigation. In humid regions drainage must frequently precede agricultural development.

(b) Equipment used

- Hand tools, digging hoes, buckets, shovels etc.;
- Animal-drawn and power-operated implements for ditching or making canals to drain excess water out of irrigated lands;
- Pumps for drainage systems;
- Pipes and fittings for drainage systems.

(c) Trends in Africa: As irrigation has not been mechanized in the majority of African countries, the subsequent development of drainage systems has not been established either. Surveys show that most of the drainage systems in the humid tropic areas of Africa are of open drain types. Owing to the lack of local manufacturing facilities for pumps, fittings, tile pipes etc., most of the countries (except Zimbabwe, Kenya, Mauritius, Egypt, Algeria, Nigeria) have greatly depended on imports of drainage equipment. As the infrastructure costs for drainage systems are high, many African countries are unable to provide adequate drainage facilities for effective irrigation.

D. Water and soil moisture measuring equipment

(a) Purpose: Efficient use of water for irrigation depends on the measurement of water stored in soils; the capacity of soils to store water is an important factor for crop production, particularly in the humid and arid regions of Africa.

(b) Equipment used

(i) Water measurement

- portable weirs;
- prashall measuring flumes equipment;

- trapezoidal flumes equipment;
- current meter;
- mechanical measuring and recording devices;
- venturi tubes and similar devices;
- float measurement equipment.

(ii) Soil moisture measuring equipment

- post hole auger;
- hand soil sampling tubes and probes;
- power auger tubes and probes;
- tensiometers etc.

(c) Trends in Africa: In almost all African developing countries, institutions for water development are mainly responsible for consumptive measurement and use of water. It is to be noted that none of the African countries have national facilities for the manufacture of the required measuring equipment. In the majority of African countries, farmers do not have adequate knowledge and facilities for water and soil moisture measurement at the farm level.

IV. TRENDS IN MANUFACTURING EQUIPMENT FOR WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE IN AFRICA INCLUDING THE ROLE OF SMALL- AND MEDIUM-SCALE INDUSTRIES

The previous chapters have highlighted the importance of national policies and strategies, as well as the existing trends in Africa in relation to the use of water conservation and conveyance, irrigation and drainage systems, and the requirements for machinery and equipment.

The analysis of product groupings and choice of machinery, equipment and devices clearly illustrates the need for a wide range of building materials and products of engineering and allied metalworking industries related to irrigation and drainage systems.

In most of the Sub-Saharan countries rain-fed agriculture is still predominant in traditional farming, and even in the limited amount of mechanized farming. The existing levels of mechanization in the majority of African countries relating to water supply, irrigation and drainage systems are very low compared to the other developing regions of the world, and the limited applications of mechanization are mostly equipped with machinery and equipment imported from outside Africa, as very few African countries manufacture such machinery and equipment. Within this complex pattern of development, an assessment is required of the interlinked development aspects of existing and future requirements for irrigation and the manufacture of the necessary equipment to fulfil these requirements, at least for selected African countries.

Existing facilities for the manufacture of equipment for water conservation and conveyance, irrigation and drainage in selected African countries

The list below shows the major product inputs for the integrated and interlinked development of water conservation, water conveyance, irrigation and drainage. Currently very few African countries manufacture locally this machinery and equipment.

1. Construction machinery and equipment

The majority of African countries do not manufacture the machinery and equipment primarily required for constructing water conservation and water supply devices. This equipment includes: (i) heavy earth-moving machinery; (ii) concrete mixers; (iii) piling equipment; (iv) excavators; (v) conveyors and mechanical handling equipment; (vi) bucket elevators; (vii) ditching machines: (viii) well-drilling machinery; (ix) well-drilling tools; (x) cranes; and (xi) transport equipment. There is a limited range of manufacturing/assembly facilities for this equipment in Zimbabwe, Kenya and Egypt. Diacarb Ltd., Zambia, is the only company in Africa which manufactures sintered diamond drilling tools.

2. Cement, concrete, bricks, masonry and pre-fabricated cast products

As mentioned in the previous chapter, water conservation, conveyance and drainage require a wide range of concrete, cement, vitrified clay and masonry cast products, including: (i) concrete water reservoirs;

(ii) concrete cast pipes; (iii) pre-cast concrete slabs; (iv) concrete joining devices; (v) brick/concrete well structures: (vi) flumes; (vii) cement for dams and other infrastructure requirements.

Cement and concrete: The majority of African countries produce the cement and concrete aggregates required for the building and construction industries. However, only a limited number of countries have manufacturing facilities for the cast cement and concrete products required for irrigation and drainage systems. These national facilities could be upgraded in Kenya, Zambia, Zimbabwe, Ghana, Tanzania, Ethiopia, Nigeria, Egypt, Algeria, Zaire etc.

Clay, bricks and masonry products are being manufactured domestically by most African countries. The domestic industries should be upgraded in order to be able to supply the requirements for irrigation and drainage systems.

3. Iron and steel products

The major requirements of iron and steel products for water conservation, conveyance, irrigation and drainage are:

Cast iron: including: cast-iron spun pipes, fittings, implements, parts etc. There are a few foundries that manufacture spun pipes in Africa, e.g. in Zimbabwe, Egypt and Kenya. In addition, a number of countries have manufacturing facilities for the cast-iron fittings and cast-iron parts required for agricultural implements. There are about 150 foundries in Eastern and Southern African countries.

Steel sections: including: (i) reinforcing steel rods and wires; (ii) commercial mild steel sections; (iii) steel sheets and plates; (iv) steel pipes and tubes; (v) steel hardware items; (vi) forging quality steel for hand tools and implements, parts etc.

Most of the above materials are required for the manufacture of: (i) hand tools; (ii) well-drilling tools; (iii) pre-fabricated low cost water control structures; (iv) fabricated metal irrigation control gates; (v) fabricated flumes; (vi) portable rectangular weirs; (vii) well tubes and pipes; (viii) irrigation water delivery pipes; (ix) bolts, nuts, foundation bolts, washers etc.; (x) reinforced rods and wires for concrete structures and the building of dams.

Steel pipes and tubes: Pipes and tubes are being manufactured in the African region. Most of these pipe and tube companies are small- and medium-scale enterprises. The maximum sizes of the pipes are up to 6 inches in diameter, and they are fabricated from coiled plates and sheets. The establishements are located in Ethiopia (18,000 tons/year); Kenya (50,000 tons/year); Zambia (36,000 tons/year); Zimbabwe (100,000 tons/year); Egypt, Algeria, Nigeria, Ghana, Zaire etc. There are a few companies manufacturing steel pipes up to 3 meters in diameter, e.g. in Mauritius, Kenya, Zimbabwe, Egypt, Nigeria etc. The Tube and Pipe Industries (Pvt.) Ltd., Harare, Zimbabwe, which is the largest manufacturing company, produces 8-mm pipes to 100-mm pipes, with wall thickness of 4.5 mm and 125 mm to 200 mm, and pipes with 6-mm wall thickness, with a capacity of 30,000 tons/year.

Existing steel production facilities

Existing steel production facilities in Africa are the following:

Rolling and re-rolling mills: The majority of African countries have steel-melting and rolling mills facilities with capacities ranging from 15,000 to 36,000 tons/year; these countries include: Ethiopia, Kenya, Uganda, Tanzania, Mauritius, Zimbabwe, Zaire, Ghana, Nigeria, Togo, Algeria, Egypt, Liberia etc. The capacity utilization of these plants varies from 15 to 60 per cent of their rated capacities. The largest mini-steel plant, which is located in Zaire and called MALUKU, has an installed capacity of 250,000 tons of steel sections per annum. The plant is not in operation now.

Integrated iron and steel mills: There are four integrated iron and steel mills in Africa: in Zimbabwe, Egypt, Algeria and Nigeria (Alaja Direct Reduction Plant). The total installed capacities of these plants are 4.5 million tons of crude steel per annum. However, the actual production of these plants varies from 2.6 to 3 million tons per annum of commercial sections. There is no plate and sheet mill in Africa. Most steel sheets are produced by re-rolling of sheets imported from abroad.

Steel fabrication: Most African countries are advanced in steel fabrication. These enterprises are generally small and medium scale. Fabricated products include welded metal products, fixtures, furniture etc. In Zimbabwe, Tanzania, Uganda, Zambia, Nigeria, Zaire, Ghana, Egypt, Kenya, there are large fabrication shops manufacturing products up to 100- to 200-ton structures for industrial use. These establishments would be ideal for the manufacture of: (i) fabricated steel reservoirs; (ii) large pipes for water supply; (iii) irrigation control gates; (iv) flumes: (v) low cost water control structures etc.

4. Pumps and related products for irrigation and drainage

Pumps are important inputs for fulfilling the water supply, irrigation and drainage requirements of African countries. Pumps are generally run by diesel engines, petrol engines, windmills, electric motors, solar energy etc. In addition to this, hand pumps and animal-drawn pumps are extensively used in Africa.

Manual, animal-drawn and windmill pumps

These pumps are mainly used for low-lift water delivery. Only a few African countries manaufacture (i) lever-type hand pumps; (ii) rotary-type hand pumps; (iii) animal-drawn hand pumps; (iv) windmill reciprocating pumps. These pumps are manufactured in the following countries:

Hand pumps are manufactured in Kenya, Zimbabwe, Zambia, Egypt, Algeria, Ghana, Nigeria, Zaire. Countries such as Ethiopia, Uganda, Sudan, Côte d'Ivoire etc. have already developed hand pumps at the research and development level only.

Hand rotary pumps: Only Zimbabwe manufactures such pumps.

Windmill pumps: Windmills and reciprocating pumps are manufactured in Zimbabwe, Kenya, Egypt, Algeria and Ghana. The most up-to-date design is available from Sheet Metal Craft Ltd. in Bulawayo, Zimbabwe. (ref. p.37, first paragraph).

Animal-drawn pumps: Animal-drawn pumps are manufactured in Ghana. Most of these pumps used in Africa are imported from abroad.

Engines and electric motors for pumps

The application of power-operated pumps for irrigation and drainage systems is increasing in Africa. In the arid and semi-arid parts of the continent, i.e. Botswana, Sudan, Morocco, Somalia, Egypt, Libya, Algeria, Mali etc., substantial numbers of engines and motors are being imported to sustain the supply of ground and river basin water for irrigation.

Diesel engines and petrol engines

The most popular motors for pumps used for irrigation are single-cylinder diesel engines ranging from 2 hp to 100 hp. None of the African countries manufacture diesel and petrol engines for driving these pumps. Most of the engines are imported from Asian and European countries. In some countries there are assembly facilities for the local supply of engines.

Electric motors for pumps

Different types of electric motors are being manufactured in Zimbabwe and in Egypt. The majority of African countries import motors from Asian and European countries. A substantial range of motors with 80 per cent to 90 per cent indigenous content are being manufactured by Relmo Electric Motors (Pvt.) Ltd., in Harare, Zimbabwe. The manufacturing range includes:

- Mini-motors, 0.22 - 1.5 kW single phase 220 V;
- Mini-motors, 0.18 - 0.95 kW 3-phase 220 V;
- Medium size motors, 0.75 - 200 kW 3-phase 380 V;
- Large size motors, 7.5 - 350 kW 3-phase 380 V.

There are some assembly plants in Kenya, Zambia, Algeria, Nigeria for medium-size electric motors. Within Africa, the application of electric motors for irrigation and drainage is very limited, particularly on small farms.

Power-driven pumps for irrigation and drainage

Power-operated pumps are an effective means of providing a large water supply to irrigate lands and of draining off excess water, when and as required. The most widely used pumps in Africa are centrifugal horizontal and vertical pumps. In addition to centrifugal pumps, the following pumps are used for irrigation, particularly in the arid and semi-arid areas: (i) deep-well turbine pumps; (ii) submersible turbine pumps; (iii) propeller and mixed flow pumps; (iv) rotary pumps; (v) open and closed diaphragm pumps.

Zimbabwe and Egypt are the two countries where pumps are domestically produced with 80 to 90 per cent indigenous content. Zimbabwe manufactures centrifugal pumps, submersible pumps and rotary pumps for irrigation purposes. Centrifugal pumps are also being manufactured in limited quantities in Kenya and Ghana. Recently Tanzania has developed a centrifugal pump in National Engineering Ltd., Dar-es-Salaam. A pump factory will be commissioned shortly in Ethiopia with a production capacity of 1,500 units per annum. Nevertheless, presently most pumps used in Africa are imported from Asian and European countries.

5. Water fittings for supply of irrigation and drainage water

The major fittings required for water supply, irrigation and drainage systems include: (i) valves; (ii) bends and elbows; (iii) hardware items; (iv) taps and cocks; (v) pipe joints etc. The manufacture of these items requires foundry, forging and machining facilities at the national level. Some African countries, i.e. Zimbabwe, Kenya, Egypt, Ghana, Algeria, Zambia, have facilities to manufacture a wide range of these fittings. The majority of African countries are net importers of these fittings, both for domestic and agricultural use. Recently Ethiopia has been considering setting up a malleable iron fittings factory near Addis Ababa with an annual production capacity of 2,000 tons. Many African countries have manufacturing facilities for brass taps and cocks.

6. Agricultural implements for constructing irrigation and drainage systems

In order to furrow land for irrigation, the following agricultural implements are extensively used in Africa:

(i) Hand tools: spades, digging forks, cultivators;

(ii) Animal-drawn implements: ridgers, disc ploughs, levellers, disc harrows etc.;

(iii) Power-operated implements: multi-purpose blade terracers, ridgers, disc ploughs, disc harrows, levellers, deep furrowing implements.

Hand tools for constructing irrigation systems

The majority of African countries have facilities at the small- and medium-scale level for the production of hand tools for levelling and furrow-making requirements, e.g. Ethiopia, Kenya, Uganda, Tanzania, Zambia, Zimbabwe, Rwanda, Zaire, Egypt, Ghana, Angola, Benin, Sierra Leone, Guinea, Algeria, Congo etc. The output of these establishments is extremely low, except in Zimbabwe, Tanzania and Kenya, owing to acute shortages of forging quality steel. The capacity utilization of these establishments ranges from 15 to 80 per cent. There are three large establishments for the manufacture of hand tools operating in Zimbabwe, the largest producer in the region.

Animal-drawn implements for constructing irrigation systems

Only some African countries have facilities for the local production of animal-drawn implements, e.g. Kenya, Zimbabwe, Zambia, Nigeria, Ghana, Egypt, Togo, Zaire, Algeria, Benin etc. The manufacturing activities in these countries are at the small- and medium-scale enterprise level. The majority of African countries import animal-drawn implements.

Power-operated irrigation implements for constructing irrigation systems

There are only four African countries that manufacture power-operated implements for levelling, ridging and furrowing, i.e. Zimbabwe, Egypt, Algeria and Kenya. Only Zimbabwe manufactures a wide range of these implements with 100 per cent local content. There are assembly facilities for power-operated implements in Ethiopia, Zambia, Zaire, Nigeria etc. The application of power-operated implements for the construction of irrigation systems is very limited in the majority of African countries. Most power-operated implements used in Africa are imported, mainly from European countries.

7. Equipment for sprinkler irrigation

There are only four countries that manufacture sprinkler irrigation equipment, i.e. (i) fixed nozzle sprinklers; (ii) perforated pipe sprinklers; and (iii) rotating boom sprinklers. These countries are Zimbabwe, Zambia, Egypt and Kenya. There are two companies that manufacture heavy duty boom-type rotating sprinklers in Zimbabwe, Tinto Industries and Dunwell Products in Harare. Besides this, there are a number of small foundries in Zimbabwe that manufacture light-duty rotating sprinklers. In most of the arid and semi-arid regions in the African continent, sprinkler systems are imported from European countries.

The majority of African countries do not have manufacturing facilities for water-supply, irrigation and drainage equipment; Zimbabwe, Egypt and Kenya are the only countries where adequate infrastructure and limited manufacturing facilities currently exist for the production of irrigation and related equipment.

The role of small- and medium-scale enterprises in the manufacture of water conservation, water conveyance, irrigation and drainage equipment

The following is a brief summary of the role of small- and medium-scale industries in the production of water-supply and irrigation equipment. It is necessary for the majority of the African countries to upgrade and expand the existing small- and medium-scale enterprises, particularly in the engineering and allied metalworking industries, so as to be more involved in the manufacture of water-supply and related irrigation equipment. The major advantages of the small- and medium-scale enterprises are the following:

- They provide greater employment opportunities for skilled and semi-skilled operatives;

- Due to their diverse production ranges, they are the main source for developing middle and higher management personnel;

- They accelerate technology development and harmonize industrial growth with respect to other industries;

- They promote accelerated adaptation and absorption of imported designs for local manufacture;

- They encourage the development of local designs to pursue improved manufacturing techniques;

- They create interlinked development of a wide range of products and offer themselves as focal points and subcontracting centres to other industries;

- They promote back-up engineering service facilities, e.g. foundry, forging, heat treatment etc.;

- Finally, they promote the integrated and interlinked development of building materials, engineering and allied metalworking industries with minimum investment, maximum productivity and multiplier effects, particularly in the rural sector.

Such concepts of the expansion and upgrading of small- and medium-scale production units will no doubt pave the way for the future manufacture of water-supply, irrigation and drainage equipment in the majority of African countries. This can be best achieved through the enlargement and establishment of core engineering industries, e.g. foundry, forging, heat treatment, machine shop and tool-room operations at the national level.

V. INTERNATIONAL TRADE IN MACHINERY AND EQUIPMENT FOR WATER SUPPLY, IRRIGATION AND DRAINAGE IN AFRICA

As reported in the previous chapters, the majority of African countries do not manufacture the machinery, equipment and devices essential for water-supply, irrigation and drainage systems. Even local pipe production in almost all African countries requires the import of coil steel sheets. According to the ECE Bulletin of Statistics on World Trade in Engineering Products for 1979 to 1984, covering the exports by 36 major exporting countries (out of wich 14 are developing countries) to Africa, these exports represent 99 per cent of the world trade with Africa in agricultural machinery. As irrigation and related machinery and equipment are part of the agricultural machinery industry, which is a subsector of the total machinery and transport equipment sector, it is necessary to review the performance of this subsector within the context of world exports to the African region.

The table on page 30 shows the exports of engineering products required for irrigation and related agricultural machinery to Africa by the main exporters from Asia, Latin America, Europe and North America. The figures for the period 1979 to 1984 show a gradual increase of exports to Africa of total machinery and equipment from $27.405 billion f.o.b. in 1979 to a peak of $40.495 billion f.o.b. in 1981, and thereafter a decline to $27.570 billion f.o.b. in 1984. This sharp decline was perhaps caused by the following: (i) lack of foreign exchange availability in most of the African developing countries; (ii) sharp reductions in industrial and agricultural activities at the national level; (iii) decrease in demand for agricultural machinery due to the drought, as farmers did not have enough money to purchase essential machinery and equipment.

At the branch level, exports to Africa of agricultural machinery and related equipment declined (i) from $682.5 million (1981) to $578.1 million (1984) of diesel and petrol engines for agricultural purposes; (ii) from $488.2 million (1981) to $303.6 million (1984) of agricultural machinery; (iii) from $232.8 million (1981) to $180.9 million (1984) of agricultural pumps; (iv) from $481.8 million (1981) to $237.6 million (1984) of civil engineering plants for water conservation and irrigation purposes. This major decline in the demand for agricultural machinery and equipment as a whole in Africa may be attributed to the continued drought and related crisis in a large number of African countries. In reality the farmers in the drought-affected areas during 1982-1985 could not afford to purchase agricultural machinery in general, nor irrigation and related equipment in particular, to alleviate the situation.

Owing to the lack of the infrastructure necessary for the utilization of ground water, countries were unable to import essential water-pumping and delivery equipment. This is the main reason why there was a substantial reduction in the exports to Africa of construction equipment, engines, pumps, agricultural implements etc., which constituted only 0.5 to 3.0 per cent of total exports of machinery and transport equipment to Africa during 1984.

In order to fulfil the future requirements for irrigation and drainage equipment, it is essential that African planners and policy-makers take more into account the integrated aspects of development and the creation of an interlinked infrastructure for the conservation, supply and utilization of water for effective irrigation and drainage.

TOTAL EXPORTS TO AFRICA OF ENGINEERING PRODUCTS RELATED TO WATER CONSERVATION, WATER SUPPLY AND IRRIGATION EQUIPMENT (SITC REV. 2. SECTION 7) BY THE MAIN EXPORTERS TO AFRICA 1/

US$ million f.o.b.

Products	SITC Rev.2 Code	1979	1980	1981	1982	1983	1984
Total Machinery and Transport Equipment	7	27,405.8	36,915.9	40,495.9	33,677.5	28,714.0	27,570.0
Total Internal Combustion Piston Engines	713	769.8	1,079.9	1,256.4	1,153.9	776.1	847.7
(a) for industrial purpose 60%	(a) 4/	461.9	647.9	753.8	692.0	465.7	508.6
(b) for agricultural purpose 40%	(b) 4/	307.9	432.0	502.6	461.9	310.4	339.1
Engines and Motors Non-electric	714	336.2	339.3	299.6	357.4	280.1	361.3
(a) for industrial purpose 40%	(a) 4/	134.5	135.7	119.9	143.0	112.0	144.5
(b) for agricultural purpose 60%	(b) 4/	201.7	203.6	179.7	214.4	168.1	216.8
Agricultural Machinery 2/	721	246.4	344.8	488.2	394.5	361.9	303.6
Agricultural and Horticultural Machinery 2/	721.1.2.	174.8	254.5	348.7	275.7	222.9	186.5
Civil Engineering Contractor Plant	723	1,234.3	1,824.7	2,408.6	1,944.6	1,533.5	1,188.2
(a) industrial & domestic application 80%	(a)	987.0	1,459.7	1,926.8	1,555.7	1,226.8	950.6
(b) water conservation & irrigation 20%	(b) 4/	247.3	365.0	481.8	388.9	306.7	237.6
Pumps for Liquid	742	419.6	532.3	582.1	531.4	474.0	452.2
(a) for industrial purposes 60%	(a)	251.8	319.4	349.3	318.8	284.4	271.3
(b) for agricultural purposes 40%	(b) 4/	167.8	212.9	232.8	212.6	189.6	180.9
Other Pumps, Fans, Compressors, Centrifuges, Filtering, Purifying	743	602.2	778.7	793.3	772.4	605.3	563.9
(a) for industrial purposes 80%	(a)	481.8	623.0	634.6	618.0	484.0	451.0
(b) for agricultural purposes 20%	(b) 4/	120.4	155.7	158.7	154.4	121.3	112.9
Import of fittings e.g. pipes, etc. (Tube & Fittings) 3/	678.2	-	-	1,125,930 Tons	723,620 Tons	554,430 Tons	480,350 Tons

1/ Source: ECE Bulletin of Statistics on World Trade in Engineering Products (1979-1984)

2/ Excluding Tractors

3/ Source : ECE Bulletin of Statistics on World Trade in Steel

4/ Estimated by the Author.

VI. MODALITIES FOR THE LOCAL MANUFACTURE OF EQUIPMENT FOR WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE IN AFRICA

The modalities for the local manufacture of equipment for water conservation and conveyance, irrigation and drainage in Africa require integrated and interlinked development, at the national level, of the necessary institutional, technological, engineering, manufacturing, entrepreneurship promotion and human resources development aspects.

Institutional development necessary to promote the local manufacture of irrigation and water supply equipment

In order to promote a harmonious and effective development of systems for water conservation and conveyance, irrigation and drainage, it is desirable to create new and/or strengthen the existing national institutions responsible for water develoment in each African country.

1. Establishment of a Water Resources Development Commission

A Water Resources Development Commission should be established in each country. The Commission should consist of (i) the Water Resources Development Authority; (ii) the Water Development Construction Authority; and (iii) the Meteorological Services Development Authority. The functions of these individual authorities under the proposed Water Resources Development Commission will be:

- to liaise closely with agricultural and industrial development institutions in the country in order to create a joint programme and plan of action for the integrated and interlinked development and utilization of water resources in the country;

- to study and investigate the country's water resource potential;

- to undertake feasibility studies and the design and development of technologies for the best use of water resources in the country;

- to introduce water resources management, administration, engineering and maintenance of machinery and equipment at the national level;

- to liaise closely with agricultural and engineering development institutions in the country in order to develop and establish the construction of facilities for irrigation and drainage, such as dams, small earth dams, earth canals, wells and lined canals, and the pumping of underground water for irrigation and drainage;

- to develop the required meteorological services, particularly those needed for agricultural development.

Thus, the main duties of the Commission will be policy formulation; and planning, directing, controlling and developing water resources, particularly for irrigation and drainage.

2. Agricultural and mechanization development centres

The majority of African countries have agricultural mechanization and testing centres or stations attached to the Ministry of Agriculture. In order to integrate the activities related to the development of water-supply and irrigation, these institutions should play an important role, in co-operation with the proposed Water Resources Development Commission. Farming communities should be closely interlinked with these centres.

3. National Centre for Engineering Design and Manufacturing (NCEDM)

In order to implement the above-mentioned programme of water resources development, it is essential to create a national institution for the development, adaptation, prototype manufacture and testing of the machinery and equipment required for systems for water conservation and conveyance, irrigation and drainage. A National Centre for Engineering Design and Manufacturing (NCEDM) should be established in each African country that will assist local industries and the proposed Water Resources Development Commission to undertake the following main activities related to water resources development:

- Identification of appropriate machinery and equipment for water supply and irrigation;

- Design, adaptation, development of prototype machinery and equipment;

- Rendering technical advisory services to local industries in plant layout, process planning, production methods, design, appropriate choice of machinery and equipment for the manufacture of water-supply and irrigation equipment;

- Development of production techniques;

- Application of jigs, tools and fixture designs;

- Production control, work study and quality control, inspection etc.;

- Technical manpower development and training at the industry level;

- Development of a repair and maintenance assistance programme.

NCEDM should also liaise closely with: (i) the Water Resources Development Commission; (ii) agricultural development and mechanization research and development institutions; and (iii) local building materials, engineering and allied metalworking industries in the country.

Due to the lack of such institutions at the national level, it is presently difficult for the existing water development authorities and the agricultural centres in the majority of African countries to develop and provide the appropriate machinery and equipment (possibly through local manufacture) urgently needed for irrigation-related development.

At present, a number of African countries are seriously considering setting up NCEDMs, e.g. Ethiopia, Togo, Benin, Algeria, Sierra Leone and

Kenya. Tanzania, Egypt and Cameroon have already established such centres for engineering design, development and manufacturing.

4. Effective co-ordination with the African Regional Centre for Engineering Design and Manufacturing (ARCEDEM), Ibadan, Nigeria

The African Regional Centre for Engineering Design and Manufacturing (ARCEDEM) was established by the 23 African Member States in co-operation with the Economic Commission for Africa (ECA), the United Nations Industrial Development Organization (UNIDO) and the Organization of African Unity (OAU) in 1978. ARCEDEM has been in operation since 1980. The major activities of ARCEDEM have been the following:

- to promote the design, development, adaptation and prototype manufacture of products of engineering and allied metalworking industries, e.g. agricultural machinery, machine tools etc., for local production;

- to supply engineering designs and drawings of tested machinery and equipment to African industries for local manufacture;

- to carry out techno-economic studies for engineering industries products for local manufacture;

- to promote the development of the engineering and manufacturing capabilities of nationals of the Member States;

- to provide direct advisory services to Member States to upgrade existing industries;

- to promote entrepreneurship;

- to organize in-plant training courses in engineering design and manufacturing.

The proposed future national centres should be linked with ARCEDEM in order to further the integrated development of African industrialization, and the activities of the centres should be interlinked at the factory level.

5. Effective co-ordination with the African Institute for Higher Technical Training and Research (AIHTTR), Nairobi, Kenya

The African Institute for Higher Technical Training and Research (AIHTTR) was established by 13 African Member States in co-operation with ECA, UNDP and OAU. AIHTTR has been in operation since 1980. The programme of activities of the Institute has been concentrated around short- and medium-term workshops and seminars, in close collaboration with the national scientific and technical institutions of a number of Member States. The main purpose of this centre is to assist Member States in acquiring and developing adequate technical manpower capabilities. Among other programmes, the current programme of AIHTTR includes in-depth medium-term training in the fields of:

- Water-supply engineering;
- Farm machinery;
- Electrical motor designs and construction.

Such training courses will promote the development of capabilities related to water-supply and irrigation systems.

6. Effective co-ordination with the African Regional Centre for Technology (ARCT), Dakar, Senegal

The African Regional Centre for Technology (ARCT) has been in operation since 1980 and has 29 Member States. ARCT was sponsored by ECA and OAU. The major objectives of the Centre are: (i) the development and use of technology within the African region; (ii) strengthening of the technological capabilities of its Member States; (iii) the promotion and use of technologies suitable for the socio-economic development of the African region. The activities of the Centre include: (i) promotion of information and documentation; (ii) technological consulting services; (iii) training, particularly in the field of adaptation and development of indigenous technologies.

Thus, institutional development aspects, particularly the co-ordination and interlinkage between the water resources development institutions and the existing centres at the national and regional levels, will have an important role to play in the future development and local manufacture of water-supply and irrigation equipment.

Engineering and technological development necessary to promote the local manufacture of irrigation and water-supply equipment

The promotion of indigenous manufacture of a wide variety of equipment for water conservation and conveyance, irrigation and drainage, as described in chapter III, requires the following measures:

(i) The expansion and upgrading of engineering core industries, e.g. foundry, forging, heat treatment, machining, forming and tool-room operations at the national level;

(ii) Upgrading existing cement mills and industries manufacturing fabricated concrete products;

(iii) Upgrading existing small- and medium-scale steel plants and pipe- and tube-manufacturing units;

(iv) The establishment and upgrading of small- and medium-scale engineering and allied metalworking industries, particularly those manufacturing agricultural machinery and equipment, to be upgraded into multi-purpose production units;

(v) The creation of small- and medium-scale ancillary engineering industries.

1. Expansion and upgrading of core engineering industries

The integrated development, upgrading and expansion of core engineering industries, e.g. foundry, forging, heat treatment, machining, fabrication and tool-room operations, are vital for the promotion of the local manufacture of parts and components required for irrigation and water-supply products. It is this core sector that provides the castings; formed, pressed, machined and precision parts; and other

components required for the manufacture of pumps, filters, motors, diesel engines and well-drilling equipment, and spare parts for earth-moving equipment, transport equipment, sprinkler equipment etc. The machinery and equipment for irrigation and related uses require a wide range of parts made of cast iron, steel, brass, and aluminium in various forms and shapes, e.g. heavy duty grey cast iron, S.G. iron, malleable cast iron, high carbon cast steel, forging quality steel, copper-zinc alloys, aluminium alloys etc.

The supply of shape castings, forged parts, heat-treated parts, jigs, tools, fixtures, consumable tools, electrodes etc. is essential for the operation of local engineering industries manufacturing irrigation equipment and related products. There are about 100 foundries in Zimbabwe, over 20 foundries in Kenya, and over 50 foundries in Egypt. These countries are thus able to manufacture a wide range of agricultural implements, irrigation equipment and water-supply machinery and equipment. In Ethiopia, however, due to the lack of core industries, particularly foundry and forging facilities, no basic machinery and equipment related to water supply and irrigation requirements is produced. This is the case with the majority of African countries.

Since 1978, ECA and UNIDO have been encouraging African countries to establish the basic support facilities in the core engineering sector. Further, the Lagos Plan of Action and the Industrial Development Decade for Africa have strongly recommended that African countries take appropriate measures to establish and expand the core engineering industries sector. Countries such as Ethiopia, Sudan, Somalia, Angola, Chad, Cameroon, Benin, Sierra Leone, Togo, Central African Republic, Rwanda, Burundi, Niger, Mali, Burkina Faso, Senegal etc. should give immediate attention to the development of this sector.

2. Upgrading existing cement mills and industries manufacturing fabricated concrete products

As cement and related aggregates are important inputs for fulfilling water conservation, conveyance and drainage requirements, it is essential that measures be taken at the national level to establish and upgrade the following:

- Cement mills, quarries etc. for the increased production of cement and related products;

- Small- and medium-scale enterprises manufacturing cast concrete slabs, pipes etc. for water supply requirements;

- Small establishments manufacturing bricks, masonry products and vitrified clay products for water storage and supply requirements.

Rural industries, particularly at the artisanal level, can play a significant role in the production of these products.

3. Upgrading existing small- and medium-scale steel plants and pipe- and tube-manufacturing units

In the majority of African countries, mini-steel plants are underutilized; capacity utilization varies from 15 to 60 per cent of rated capacity. Most of these steel plants have scrap-melting facilities

with capacities of up to about 36,000 tons per year and downstream facilities for the manufacture of steel rods and wires for building and construction. It is essential that these mini-plants should be upgraded to produce more reinforcing rods and the commercial sections required for building up the infrastructure for water conservation, conveyance and drainage.

The situation of the existing pipe- and tube-manufacturing industries in African countries is similar; it is necessary to upgrade existing units for the manufacture of large-diameter pipes necessary for the provision of an adequate water supply (ref. p.22, (3.)).

4. The establishment and upgrading of small- and medium-scale engineering and allied metalworking industries

In order to manufacture irrigation and related equipment, it is essential to promote small- and medium-scale engineering and allied metalworking industries in African countries. As mixed product manufacturing is essential for the economic viability of these establishments, it is essential that a multi-purpose concept of manufacturing should be introduced during expansion or upgrading. The types of industrial development are as follows:

(a) The expansion of specific foundries and forge shops that manufacture valves, water fittings, brass taps etc., along with other products;

(b) The expansion of industries manufacturing hardware items, e.g. bolts, nuts, clamps, along with other components needed for pumps, motors, diesel engines etc.;

(c) The establishment of diesel engine-manufacturing activities in existing spare parts manufacturing or reparing units. The typical example is the Precision Grinders Ltd., Harare, Zimbabwe, which at present repairs diesel engines and can be upgraded to manufacture single- or double-cylinder diesel engines for agricultural purposes;

(d) The upgrading of existing engineering industries for the manufacture of a wide range of pumps for water lifting and delivery. Existing foundries can be upgraded to manufacture lever-type hand pumps and rotary hand pumps etc.;

(e) The establishment of an electric rotating machinery manufacturing plant on a multi-purpose production basis. A typical example is Relmo Electric Motors (Pvt.) Ltd., Harare, Zimbabwe, where the company manufactures, besides electric motors, a wide range of other products, e.g. tea-processing machinery, plastic products etc. (ref. p.24).

(f) The upgrading of existing agricultural hand-tool and implement manufacturing plants to enable them to produce devices for water control, pumps, well-drilling equipment, well-drilling tools, irrigation-control devices, power-operated implements, sprinkler equipment etc. Typical examples are Tinto Industries Ltd. in Zimbabwe, and Northland Engineering Ltd. in Zambia, companies which manufacture a wide range of metal products besides the scheduled manufacture of agricultural machinery;

(g) The upgrading of some of the metal-fabricating industries for the manufacture of windmills and solar energy equipment. A typical example is Sheet Metal Kraft (Pvt.) Ltd., Bulawayo, Zimbabwe, which manufactures windmills up to 360 mm in diameter, with a 3.5:1 gear ratio, a pump cylinder diameter ranging from 44.45 mm to 304.8 mm, and a water delivery rate ranging from 654 litres/hour to 25,226 litres/hour. On a reasonably windy day, with a wind speed of 40 km/hour from a 31 meter head, the windmill pumps 58,862 litres in 24 hours. Apart from the production of windmills, the company manufactures processing equipment for chemical industries, making it a typical multi-pupose small-scale production unit in the African region.

Another example of a multipurpose production unit manufacturing irrigation equipment with other agricultural implements and processing machinery, located in Ghana, is Agricultural Engineering Ltd., Accra. In fact, the majority of the African small- and medium-scale metalworking industries can be described as multi-purpose production units.

5.. The creation of ancillary engineering industries at small- and medium-enterprise levels

Ancillary industries play a significant role in the manufacture of mass-produced standard parts and components required for industries manufacturing diesel engines, pumps, motors, agricultural implements, fittings, fixture, and other related machinery and equipment required for water-supply and irrigation systems. Ancillary industries can produce parts and components at a lower cost than the large production units do. Although the manufacturing base of each ancillary industry of a specific product will be at the national level, it is highly desirable for economic viability if the products of the ancillary industries are marketed throughout Africa.

Since it is uneconomical to manufacture all parts and components in a production unit producing final products, the major role of the ancillary industries will be to manufacture and supply standard parts at competitive prices in order to reduce the overall cost of final products. It is suggested that the following major ancillary industries should be set up at the national level for the manufacture of water-supply and irrigation equipment:

(a) For diesel and petrol engines: piston and piston rings; crankshafts and camshafts; air and oil filters; bi-metal bearings; starter rings; engine valves; electrical starters and dynamos; gaskets, V-belts, hoses, radiators etc.;

(b) For electric motors: terminals, bearings, copper wires, laminations, starters, switches etc.;

(c) For pumps: impellers, bearings, check valves, gate valves, various pipe fittings, couplings etc.;

(d) For drilling tools: well-drilling tools, mechanical tools, agricultural hand tools etc.;

(e) For agricultural implements: tines, nuts, washers, springs, clamps etc.

(f) For steel hardware: bolts, nuts, washers, prings, clamps etc.

The promotion of entrepreneurship for small- and medium-size industries for the manufacture of water-supply and irrigation equipment

Entrepreneurship promotion is the most important aspect of interlinked policies to promote the development of small- and medium-scale enterprises for the economic manufacture of irrigation and related equipment. This requires special government concessions for private sector industries, particularly in rural areas, such as the following:

- Credit facilities to acquire machinery, equipment, factory premises and raw materials;

- Planned factory accommodation through industrial estates;

- Training schemes and programmes to attract entrepreneurs;

- Marketing facilities to promote entrepreneurship, e.g. co-operative marketing operations, government centres, marketing and export houses etc.

The promotion of entrepreneurship depends on the development of an atmosphere of confidence for investment, through government policies and realistic planning at the national level. In promoting entrepreneurship in relation to the manufacture of irrigation and water-supply equipment, the following types of enterprises should be considered:

- Irrigation and drainage enterprises;

- Private enterprises at small- and medium-scale levels for the local manufacture of machinery and equipment required for irrigation within the multi-pupose production concept;

- Individual and partnership enterprises for the infrastructural and constructional services of irrigation and drainage systems development;

- Co-operative enterprises for irrigation and water supply development.

Human resources development for the manufacture of irrigation and water-supply equipment

Human resources development for the manufacture of water supply and irrigation equipment requires the promotion of the following disciplines at the national level:

- Water supply engineering;
- Mechanical engineering;
- Metallurgical engineering;
- Production engineering;
- Maintenance engineering;
- Electrical engineering;
- Industrial engineering.

It is necessary to establish and upgrade polytechnics, vocational training centres, craft training centres, and the civil/mechanical/electrical/metallurgical faculties of universities. It is further necessary to introduce national and regional manpower development programmes, particularly at the industry level. Small- and medium-scale industries should be equipped with training centres at the factory level in order to provide the following comprehensive training courses:

- In-plant training courses on hydraulics and water engineering;
- In-plant training courses for product development and design relating to water-supply and irrigation equipment;
- In-plant training courses on foundry, forging, heat treatment, machine shop, tool room etc.;
- In-plant training courses on production engineering, methods engineering, materials testing;
- In-plant training at the higher management, middle management and supervisory levels;
- In-plant training courses on preventive maintenance.

The interlinked development of human resources requires entrepreneurship development and training programmes for the owners of small- and medium-scale industries. This can be provided within the framework of the above in-plant training courses.

In order to provide the small- and medium-scale industries with trained technical manpower, it is essential that trained manpower should be produced at the national level in the following areas, depending on the size of industrial and engineering infrastructure (the number of years of experience required is shown in parenthesis):

- For foundry and machine shop: pattern-makers (5 years); mould- and core-makers (5 years); melters (2 years); maintenance engineers (2-5 years); designers (4 years); process planners (3-4 years); quality control inspectors (4 years);
- For forging and heat treatment: metallurgists (5-10 years); die-makers (5 years); forge masters (5 years); heat treatment engineers (5-10 years);
- For metal cutting and machine shop: turner, driller, miller, borer etc. (5-10 years); supervisors (5 years);
- For cold and hot forming and metal fabrication: tool and die setters (5 years); tool setters (2-3 years); fitters (5 years); press operatives (2-2 years); tool designers (4-5 years); fabrication operatives (3-5 years); process planners (4 years); welders (5 years) etc.;
- For the tool room: tool room machine operatives (10 years); fitters (5-10 years); tool designers (10 years); die- and mould-makers (10-15 years); viewers and inspectors (10 years);

For engineering management: technical managers (10-15 years); industrial engineers (5-10 years); finance and sales personnel (5 years); methods engineers (10-15 years); work study engineers (5-10 years); production engineers (5-10 years); maintenance engineers (10-15 years); design and development engineers (10-15 years);

- For water-supply engineering: hydraulics engineers (5-10 years); construction engineers (10-15 years); civil engineers (5-10 years); maintenance engineers (5-10 years); testing engineers (5-10 years).

VII. INTRA-AFRICAN AND INTERRREGIONAL CO-OPERATION FOR THE MANUFACTURE OF EQUIPMENT FOR WATER CONSERVATION AND CONVEYANCE, IRRIGATION AND DRAINAGE EQUIPMENT IN AFRICA

As shown in the previous chapters, small- and medium-scale industries are important for the interlinked development of the local manufacture of water-supply, irrigation and drainage equipment within the concept of multi-purpose production. Substantial numbers of small- and medium-scale industries existing in the private sector, particularly in the metalworking field, in a number of African countries, may be identified as multi-purpose production enterprises involved in the manufacture of irrigation and water-supply machinery and equipment. For these existing industries and for the establishment of new small- and medium-scale industries, there is an urgent need for upgrading, expansion and rationalization of the interlinked manufacture of water-supply and irrigation equipment.

In addition to existing national development efforts, there is a need for intra-African and interregional co-operation to promote the development of this vital socio-economic cum industrial subsector.

Intra-African co-operation for the future manufacture of water-supply and irrigation equipment

Intra-African co-operation for the integrated development of water-supply and irrigation equipment manufacture can best be achieved through the following:

(a) Subregional and inter-country co-operation for the integrated planning and development of water resources, particularly for sectoral purposes, as recommended in the Mar del Plata Action Plan adopted by the United Nations Water Conference, Mar del Plata, Argentina, 14-25 March 1977.*/ Although the Action Plan stresses the primary importance of actions at the national level, the deliberations highlight the subregional and inter-country co-operation aspects for the development of water resources for irrigation, drainage, domestic water supply, sanitation, industry, hydro-power, inland navigation and other in-stream uses;

(b) Continuous vigilance for the development, promotion and establishment of linkages between water-supply and irrigation projects on the one hand, and the manufacture of appropriate water-supply and irrigation equipment in existing small- and medium-scale enterprises at inter-country and/or subregional levels, on the other hand;

(c) Inter-country identification and popularization of priority building materials, engineering and allied metalworking industries products related to water-supply and irrigation equipment that can be manufactured in one country and offered to the greater subregional markets;

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*/ United Nations publication, Sales no. E.77.II.A.2, chapter I and annex I.

(d) Organizing subregional and/or regional expert meetings and workshops for the promotion of small- and medium-scale multi-purpose production units engaged in manufacturing water-supply and irrigation equipment for a group of countries. The meetings and workshops should be oriented towards the promotion of local design and appropriate manufacturing technologies;

(e) Participation by interested countries in multinational industrial projects to manufacture water-supply and irrigation equipment in the subregion;

(f) Exchange of information and prototype adaptations for water-supply and irrigation equipment within a group of countries (ARCEDEM, already described, (ref. p.33) can be of great assistance in this);

(g) Supply of the details of products developed in a country for adaptation in the neighbouring countries;

(h) Establishment of a subregional and/or regional network for agricultural machinery development and popularization similar to RNAM, organized by the Economic and Social Commission for Asia and the Pacific (ESCAP) for selected Asian countries, particularly for the promotion and manufacture of water-supply and irrigation equipment;

(i) Organizing subregional training courses in the field of design and manufacture of water-supply and irrigation equipment best suited for existing small- and medium-scale industries;

(j) Organizing study tours within the subregion and/or at the inter-country level, particularly in countries such as Zimbabwe, Kenya, Egypt, where large numbers of small- and medium-scale industries presently manufacture water-supply and related equipment.

Interregional co-operation for the future manufacture of water-supply and irrigation equipment

Interregional co-operation for the integrated development of water-supply and irrigation equipment manufacture in Africa can best be achieved through the following:

(a) Promotion of collaboration among research institutions and local manufacturers for the adaptation of designs and prototypes, particularly for low-cost pumps, implements and machinery already developed in Asia, Latin America, Europe and North America;

(b) Promotion of joint-venture projects between existing manufacturers of water-supply and irrigation equipment located in other regions and prospective African enterprises willing to set up similar industries in African countries. Such arrangements should be carried out taking into account the upgrading of existing core engineering and building materials industries in the region.

(c) Exchange of specific designs, prototypes and manufacturing information which can be obtained from the ongoing projects such as RNAM in the ESCAP region in Asia or from specific developing countries in other regions.

(d) Organizing interregional workshops on (i) improvement and promotion of water-lifting and supply devices: (ii) strengthening of design and manufacturing capabilities; (iii) promotion of appropriate and acquisition of affordable technologies; (iv) promotion of small- and medium-scale enterprises in the core sectors: (v) manufacturing and popularization of water-supply, irrigation and drainage equipment in Africa, Asia and Latin America and the Caribbean.

(e) Organizing study tours in other regions to gain experience concerning the manufacture of water-supply and related machinery and equipment, particularly in the small- and medium-scale enterprises in Asia and Latin America and the Caribbean.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Water resources development is an indispensable and integral part of economic, social and industrial development at national and inter-country levels. Because there are many complex aspects involved in water conservation and conveyance, irrigation, drainage etc., it is important to provide a wide variety of contexts, involving numerous disciplines including the physical sciences, engineering, economics and other social sciences.

Within this context, the paper portrays the needs for national policies and strategies concerning the production of equipment for water conservation and conveyance, irrigation and drainage in Africa. The need for appropriate choice of irrigation and water supply equipment and their related manufacturing facilities at national level demands the creation and interlinked development of building materials, metallurgical, engineering and allied metalworking industries. Such harmonious development further requires interlinked institutional, technological, engineering, and manufacturing development, as well as entrepreneurship promotion and comprehensive human resources development. These development modalities, the paper suggests, can only be achieved through upgrading and expansion of small- and medium-scale enterprises, which are the real carriers of industrial development in general, and agricultural machinery industries development in particular, in Africa.

The upgrading and expansion of these small- and medium-scale enterprises for the manufacture of water-supply and irrigation equipment require the promotion and establishment of foundry, forging, heat treatment, machining, metal-fabrication and tool-room operations at the national and subregional levels. The development of ancillary industries and the promotion of subcontracting arrangements play a significant role in the intensification of the manufacture of water-supply and irrigation equipment.

All these related activities require the promotion of multi-pupose production aspects within the existing manufacturing activities in Afria. In order to give an accelerated thrust to the above development parameters, it is necessary to organize intra-African and interregional co-operation on various aspects for the integrated and interlinked development of water-supply and irrigation equipment manufacture in engineering and allied metalworking industries.

Water is basic to agriculture, which accounts for some 80 per cent of the total water consumption in this planet. Therefore, the Mar del Plata Action Plan, adopted at the United Nations Water Conference in 1977, requested through its resolutions and recommendations a wide spectrum of activities in the field of integrated water resources planning and development, particularly for agricultural use. In order to implement the Mar del Plata Action Plan, it is necessary to promote the agricultural machinery industry within the engineering and allied metalworking industries subsector. Such a strategy will provide local manufacture and supply of a wide variety of agricultural machinery and equipment, particularly essential water-supply and related equipment.

This will thus support the implementation of the Mar del Plata Action Plan for overall development of water resources and its effective use for the benefit of African people.

Therefore, to plough a new furrow towards alleviating the present crisis, this paper concludes with the following recommendations based on an integrated and interlinked approach towards the manufacture of water-lifting, storing, supply, irrigation and drainage machinery, equipment and devices. This can only be achieved through the promotion of small- and medium-scale enterprises with mutli-purpose production objectives throughout Africa.

Recommendations

The following are the proposed recommendations to the Third Consultation on the Agricultural Machinery Industry regarding the manufacture of water conservation and conveyance, irrigation and drainage equipment and devices in small- and medium-scale multi-purpose production units in Africa.

1. At the national level

   (a) The foremost consideration will be to integrate the planning of manufacturing activities related to water-supply and irrigation equipment within the framework of national water resources development and planning, as reflected throughout the Mar del Plata Action Plan.

   (b) In order to bring about overall integrated development aspects, it is necessary to plan all the activities related to the governmental and non-governmental institutions and the private and public sector industries responsible for the planning, development and implementation of water resources projects down to the manufacture of finished products required for water-supply, irrigation and drainage development. In this process of development the end-users, i.e. the farmers, industrialists, and water consumers, should be consulted.

   (c) It is necessary to promote the effective conservation, supply and use of ground water as opposed to the traditional rain-fed agriculture. This requires overall national planning for the detailed varities of machinery, equipment and devices required for water-supply and related irrigation systems in the arid, semi-arid and even in the tropical humid regions of the African continent. A survey should be undertaken urgently throughout the African region and in each African country to assess and produce an inventory of the varieties of machinery, equipment and devices for water-supply and irrigation systems, as well as a survey of local industries suitable for manufacturing such products. If necessary, new industries should be created to undertake future manufacturing activities.

(d) Apart from the creation and upgrading of existing water resources development institutions, it is of paramount importance for every African country to establish a National Centre for Engineering Design and Manufacturing (NCEDM). Such centres will help the local industries to develop indigenous technologies and adapt affordable foreign technologies through prototype development, and support them through the supply of detailed manufacturing designs and the provision of process planning facilities. Such centres will also help to develop human resources and promote entrepreneurship. Each of these centres at the national level should be linked with the African Regional Centre for Engineering Design and Manufacturing (ARCEDEM) in Ibadan, Nigeria.

(e) In order to promote self-sustained development of local manufacture of a wide range of water-supply and irrigation equipment, it is recommended to expand and upgrade the building materials, metallurgical and core engineering industries, such as cement mills, iron and steel mills, foundry, forging, heat treatment, machining, fabrication, and tool-room activities, at the national and subregional levels in Africa.

(f) It is recommended to upgrade the existing and to create new small- and medium-scale enterprises for the manufacture of water-supply and irrigation equipment. It is necessary to formulate definite programmes at the national level for the promotion of small-scale industries. Such promotion activities should be oriented towards the creation of substantial ancillary industries and greater subcontracting arrangements for the parts and components required for water-supply and irrigation machinery and equipment. The entire concept of this promotion should be directed towards enlarging the activities of the agricultural machinery industry within the engineering and allied metalworking industries subsector, following a multi-purpose production concept (ref. pp. 36-37 (4) and (5)).

(g) As a prerequisite to the above recommendation, it is necessary to provide government assistance and subsidy for private small- and medium-scale enterprises. There is a need to provide a package of incentives, e.g. subsidized rent in industrial estates, raw material subsidies, low interest borrowing of working capital, government hire-purchase schemes for machinery and equipment, tax holidays, subsidized training arrangements, consumer incentives for the products purchased from the small- and medium-scale sector, particularly for agricultural use (ref. p.38).

(h) The integrated and interlinked development aspects of the local manufacture of water-supply and irrigation equipment can only be achieved through integrated programmes for human resources development. This can be achieved through the intensification of in-plant training courses for industrial operatives and entrepreneurship training facilities for the owners of small- and medium- scale enterprises, including the organization of seminars, workshops and study tours within and outside the countries (ref. p.38).

2. At the subregional or inter-country levels

(a) It is necessary to undertake inter-country or subregional projects for water resources development by utilizing common rivers, streams, and lakes for irrigation. This requires inter-country joint action programmes for water-supply, irrigation and drainage development.

(b) Due to the severe constraints in the majority of African countries on the availability of essential raw materials in the manufacturing sector, it is recommended to upgrade the existing cement, iron and steel mills in the subregion for the effective supply of necessary inputs.

(c) It is recommended to promote inter-country or subregional ancillary industries and selected capital goods industries for the manufacture of diesel engines, motors, pumps etc. required for water supply and irrigation systems. The report on the Engineering Industry Development Programme for Eastern and Southern African Preferential Trade Area (PTA) regions recently completed by ECA/UNIDO/PTA and the Government of India should be taken into account for this recommendation.

(d) It is recommended to organize subregional workshops, seminars and study tours for the promotion of the local manufacture of water-supply and irrigation equipment and the exchange of existing prototypes already developed for future local adaptation and subsequent manufacture in Africa.

(e) In order to further strengthen the above recommendation, UNIDO/UNDP should be requested by the African subregional institutions to establish a subregional network for agricultural machinery development projects for the development of water-supply and irrigation equipment similar to that of RNAM organized by IRRI/ESCAP/UNIDO and UNDP in the Asian region.

3. At the regional level

(a) It is recommended that the majority of African countries should be members of the existing regional institutions, e.g. ARCEDEM, AIHTTR and ARCT, for the effective use of these centres for the future promotion and progressive manufacture of water-supply and irrigation equipment. It is further recommended that ARCEDEM should give top priority to the design, development, and prototype-manufacture of essential water-supply and irrigation equipment urgently required by the Member States.

(b) In order to achieve self-sustained development objectives at the regional level, it is suggested that UNIDO, in co-operation with ECA and other existing regional institutions in Africa, should organize the Second Regional Consultation on the Agricultural Machinery Industry in 1988 oriented towards alleviating the crisis prevailing in most of the African regions.

4. At interregional levels

(a) It is recommended to organize workshops, seminars and study tours in selected Asian and Latin American countries to enable African policy-makers and entrepreneurs of small- and medium-scale industries currently involved in agricultural machinery manufacture, particularly the manufacture of water-supply and related equipment, to witness how the agricultural machinery industry has been developed in these regions.

(b) It is recommended to exchange prototypes, designs and related manufacturing information for water-supply and irrigation equipment between African countries and some selected advanced countries in the other regions. Projects such as RNAM and IRRI in the Asian region may have a significant role to play in these co-operation activities.

(c) Entrepreneurship training programmes on water-supply and irrigation equipment manufacture should be organized in selected advanced developing countries in Asia and Latin America for African proprietors of small- and medium-scale enterprises. The training cost of the African proprietors should be funded by the respective African Governments as an incentive for industrial development. The programmes will be organized by bilateral or multilateral funding, under the auspices of UNIDO, in close co-operation with FAO and other international organizations.

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